



RAPTOR RESEARCH NEWS

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The editors wish to thank all of our readers for their contributions or subscriptions. We hope that you will understand that it is impossible to send a personal thanks to each of you. Likewise we have been unable to answer all inquiries personally, but with your forbearance we hope to do so as soon as possible. We always welcome items for the News.

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BOARD OF DIRECTORS MEETING

The Board met at SDSU in Brookings, South Dakota on February 23. George Jonkel was added to the Board, and terms were set as follows to provide for future regular elections for three year terms: Springer, 1 year, Hunter, 2 years, Jonkel 3 years, Harrell 4 years. The Board felt a need for a more formally organized structure and established four offices and held elections. The officers elected are listed on page 14.

The members discussed and voted for changes in the Bylaws and Articles of Incorporation to agree with tax exemption requirements. These were passed and copies have been sent to the appropriate tax office.

It was decided that new projects that are involved with birds obtained by permits through the Foundation for the breeding project should be evaluated; a form for the prospective cooperator to fill out was discussed and has since been prepared. The Board will evaluate any such proposal and when desirable, refer it to one or more Advisory Board members. The original associates in the breeding project had earlier developed a policy that birds obtained through the Foundation not be used for falconry, a policy since confirmed by the Board of Directors. This of course does not mean that birds otherwise obtained and used for falconry be excluded from the project. It is hoped that planning can be adequate so that requests for permits can be reasonable and that obtained birds can be well kept and be fully used by the program.

Other matters discussed included the newsletter and committees. It is hoped that committees can be appointed in the near future to move forward certain special areas of raptor research (summary by B. E. Harrell).

BREEDING PROGRAM INFORMATION EXCHANGE

In the initial organization of the Raptor Research Foundation those involved with the breeding program exchanged information by means of a round-robin method of sending carbon copies of their letters to the other participants. There are now more participants and a number of others who would like to keep up on this information. The Raptor Research News does not take the place of these exchanges for the News is not issued often enough, there is sometimes a delay from the time of preparation until it is in the mail, and the News is probably not the best place for the occasional thoughts that may be stimulating to another cooperator but would ordinarily end up under the editors' red pencils as too long or too hypothetical for many of the readers.

With these thoughts in mind we have set up a system of handling this information. Cooperators in the breeding project will be asked to type up their thoughts and observations on duplicator masters and to mail them to a central source by the first of the

month. These will be duplicated, assembled, and copies sent out to all cooperators and to those members who write us that they wish to be on this mailing list. Any material received after the deadline will be saved for the next month. Before each Raptor Research News comes out the preceding material will be abstracted and reported in the News. It is felt that such an abstract will probably take care of most people's needs and the R.B.P.I.E. will retain its necessary informality.

We are fortunate to have the cooperation of Tom Dunstan, a graduate student working in raptor research at the University of South Dakota, who will take care of the mechanics of the system.

Workers already involved in the breeding project will receive duplicator masters and requests to submit monthly comments. If you are beginning a breeding project, please request masters from Mr. Tom Dunstan, Zoology Department, University of South Dakota, Vermillion, S. Dak. 57069. For those who feel that the quarterly abstract of information appearing in the News is insufficient, please send a card asking to be put on the mailing list for the B.P.I.E. to Mr. Don Hunter, Centerville, S. Dak. 57014.

BREEDING PROJECTS

Purpose, Problems, Progress, and Potentialities

For thousands of years man has formed associations with birds of prey. He has identified himself symbolically and emblematically with them and their observed or imagined prowess. He has employed them as hunting allies, and even as military allies but never has he developed a technique of inducing them to reproduce regularly in captivity. Perhaps he recognized no necessity to try very hard. After all many were considered in competition with hunting and farming man and were doing well in spite of persistent persecution. But now some are not doing so well in spite of protection. It is hoped that there are yet time enough and numbers enough to allow the acquisition of an understanding of the biology, ecology, and ethology of these threatened species sufficient, at least temporarily, to stave off extinction. The efforts necessary to achieve this goal are worthwhile to some of us who have the appreciation and motivation and hopefully the understanding of the problems and what it will take to solve them. The response by very knowledgeable persons to our invitation to participate in Raptor Research Foundation is a source of considerable personal satisfaction.

The captivity breeding projects are receiving high priority as it is felt that success in developing these techniques will provide, among other things, a most useful research tool. An important byproduct, we think, will turn out to be the uncovering of problems both biological and psychological that might otherwise go unnoticed until too late. To equate captivity behavior with wild behavior is certainly dangerous since behavior is to some degree at least related to environment. However, patterns have

and will most certainly continue to manifest themselves. These patterns it is hoped will give clues as to the nature of the behavior, e.g., whether it is innate, learned, or some of both. With this knowledge we should be able to predict success of changes in techniques to fit circumstances, re-establishment of lost populations, along with a myriad of other management problems.

We are interested in exploring the possibility of artificial stimulation--light, temperature, hormones, etc. The latter will involve the solution of some difficult problems in endocrinology. We are working on learning a technique of testing for gametogenesis. Given this tool we hope to eliminate some dark areas such as the relationship of gametogenesis to the molt and to the behavior pattern. Artificial insemination possibilities are being explored and there is reason to believe that this may be a feasible answer to the problem of infertile eggs. There is the problem of adequate but inexpensive quarters; we hope to be able to recommend facilities that are adequate for the program to be followed. This will need to be based on experience and it may take a bit of time.

These are a few of the problems to be solved. There are of course many others and more will surely crop up. We feel that significant progress has been made.

One of the most attractive potentialities of successful breeding technique is the re-establishment of lost populations. That this is capable of being done seems to us most probable, particularly in view of Joe Simonyi's experience (see Raptor Research News 1(1):4, Jan. 1967). That all of our goals are attainable we certainly believe. All we must have is time and resources. The greater the resources the shorter the time needed, and the shorter the time given the greater the need for resources.

Though the percentage of the human population who really care may be relatively small, the dedication of those who do will see this project through to a successful conclusion. If we need further justification, it appears that all life on the planet is in some way interdependent and pieces to our puzzle will fit in others. Our goal should be to add to the fullness of life through knowledge and understanding. (Editorial by Don Hunter).

BREEDING PROJECTS: News and Questions

Bald Eagle. Daniel P. Mannix 4th, Sunnyhill Farm, R.D. #2, Malvern, Penna., 19355, writes the following in a recent letter to us.

"I have an American bald eagle, female, 30 years old, who has laid two eggs every year for the last five years. I have just obtained a gray headed sea eagle from Russia, four years old and a male. Neither has ever been exposed to DDT and as they are both *Haliaetus* I hope to mate them. Do you know of anyone who has successfully bred eagles in captivity?"

Golden Eagle. Dr. Frances Hammerstrom reports that her Golden Eagle with her help constructed a nest last year and laid two eggs. She is considering the possibility of artificial insemination and inquires as to the possibility of obtaining viable Golden Eagle semen. It is too late for this year but she would like to make plans for next year. Address: Plainfield, Wisconsin.

Breeding of Immatures. An interesting note by John Flavin:

"I have some notes on breeding by immature hawks which may interest you. I had a young female kestrel in Denver which I released in March of her first year. She subsequently raised a family of five. She had five impeded primaries on one wing and TEN on the other. She went through a complete molt by September. Incidentally, she had been in a cage for three months before I obtained her and didn't learn to fly until mid-September.

"In California I found a red-tail nest at which the male bird was in immature plumage. They hatched three young.

"There is a well known and beautiful Fuertes painting of peregrines in "BIRDS OF AMERICA" which depicts an immature male and a haggard female raising two young. Fuertes was deeply interested in birds of prey, and I believe a falconer. It is unlikely that he would paint such a scene if he didn't have first hand knowledge that it had actually taken place."

Beebe's Peregrine Falcon. Frank Beebe reports that his pair of Peregrines, which produced three infertile eggs last year, have this year laid an initial clutch of four eggs. These were removed and placed in an incubator. After a period of incubation these too proved to be infertile. At last report a second set of eggs was started. There have been indications of increased sexual activity between the birds and hopes are high that this second set will be fertile. Some observations last year led Beebe to suspect that the male may not have started his breeding cycle as soon as the falcon (female). This is one reason for programming this year's trial to remove the first set with the hope of recycling on the part of the female.

Austing's Red-tailed Hawks. Austing writes:

"My red-tails were a bit late this year, first egg March 21, second March 24. Same procedures as previous years so nothing new to report. I'm hoping both eggs are fertile and produce a pair, in which case I'll keep them and see what a brother-sister team might produce."

Kendall's Prairie Falcons. On March 22 the female Prairie Falcon of the pair in Henry Kendall's breeding project laid the first of five eggs. This is an eyass pair; the male is 3 years old and the female, 5. More will be written on these birds in a later issue when more can be reported. Kendall has kept detailed notes on the care and handling of his birds.

INJURIES, INFECTIONS, AND ANTIBIOTICS

Those working with raptors are often confronted with problems of injured birds, at least we have had a procession of injuries brought to us mainly the result of gunshot wounds or collisions with wires. We would like to pass on our observations in hope that they may be of help to someone and to encourage others who have hints on raptor therapy to report to the News.

The first danger in wounds is of course infection. Broken bones are often, probably usually, accompanied by infection to both the bone and the soft tissue of the break area. If the infection can be controlled, the bone will heal in a surprisingly short time. As a result of conversations with Col. MacIntyre of the Air Force Academy, Dr. Morgan Berthrong of Colorado Springs, and Dr. Eric Awender of Freeport, Illinois and Dr. Myron C. Krominga, DVM of Centerville, S. Dak., we have used the following procedure with success. Cleanse wound to remove foreign material but take care not to aggravate or increase the injury. Set bone if practical (if bone is anywhere near proper position we leave it alone). Treat locally with antibiotic combination. We have used successfully a product designed for treatment of mastitis in cow udders, injecting directly into the wound periodically (twice a day). Administer orally one to two hundred thousand units of penicillin G. Tablets may be powdered and picked up on the food or hand administered wrapped in a piece of meat. Continue for seven to nine days. The diet of course should be nutritionally complete. We are, wherever possible, staying away from injectables, as evidence indicates that raptors are sensitive to shock from their use. Many broad spectrum antibiotics would undoubtedly be useful, but due to our lack of experience with them in raptors and the apparent danger in their use we recommend caution. There is evidence of vitamin depletion accompanying use of antibiotics, so use should continue only as long as is necessary.

We might add that birds that are crippled may, none the less, be of value to research projects. (Report by Donald V. Hunter, Jr.)

COLLEGE AND UNIVERSITY RAPTOR RESEARCH

The editors request that our academic friends prepare brief reports on current and recent raptor research activities at their schools.

University of South Dakota, Vermillion, S. Dak. Work on raptors is under the supervision of Dr. Byron E. Harrell in the Zoology Department. Harrell is President of the Foundation and Co-editor of the News. He is working on tape-recorder playback techniques for studying owls and cooperates with Don Hunter's breeding project at Centerville, South Dakota. Currently Mr. Rory N. Vose is working on a predator-prey study of Screech Owls and radioactively tagged White-Footed Mice for a Ph.D. thesis. Mr. Thomas C. Dunstan has nearly completed an M.A. thesis on the ecology of the breeding

Osprey population in a county in northern Minnesota. Another M.A. thesis which is nearing completion is on the local population of raptors in a part of southeastern South Dakota by Mr. Daniel J. Call. Both Mr. Dunstan and Mr. Call anticipate working on raptors in their Ph.D. work. Recently completed theses include a study of Bald Eagle populations wintering in South Dakota and breeding in northern Minnesota (Ph.D.) by Dr. Alfred H. Grewe, Jr., now at St. Cloud State College, Minnesota, and a breeding study of Great Horned Owls in a part of southeastern South Dakota (M.A.) by Mr. John Behrends, now at Mankato High School, Mankato, Minnesota. Another study was made of the territory of Screech Owls by the use of tape recorder playback by Mr. Eugene Bawdon, now at Eastern Arizona Junior College, Thatcher, Arizona. In addition, some banding of raptors is conducted and arrangements are being made to begin some pesticide analyses. (Report by B. E. Harrell)

GOLDEN EAGLE COOPERATIVE STUDY*

Cutting through the ignorance and mistrust that have too often split conservationists and eagle-shooting ranchers into warring camps, the National Audubon Society and the National Wool Growers Association have joined in a study to bring new understanding to the problem of how to protect sheep rancher's livestock without endangering the survival of the golden eagle. The Wool Growers and Audubon, along with the Bureau of Sports Fisheries and Wildlife, will undertake the one-year study to get factual data on the golden eagle and the threat it poses to ranchers.

A policy committee has been established, with representatives from the three organizations, to review the research project and the personnel selected for carrying it out. Carl W. Buchheister, President Emeritus of the National Audubon Society, will be the Society's representative on the committee.

In his final months as president of the National Audubon Society, Mr. Buchheister worked to improve relations between conservationists and the Wool Growers by traveling to their headquarters in San Angelo for talks and inviting them to do the same in New York City. During the meetings, which were both formal and informal, it became clear that the rancher is more of a conservationist than many people--especially easterners--give him credit for, because of his dependence on natural resources. To portray him as a killer who likes to poison or shoot eagles is to misrepresent him. At the same time, Mr. Buchheister found it necessary to point out to the ranchers that the Audubon Society is not composed of "sentimental bird watchers" flatly opposed to all controls on all predators. Rather it is composed of people who believe in the rancher's right to protect his property, as well as in the eagle's right to survive.

*Quoted from the National Audubon Society's "Audubon Leader's Conservation Guide," Vol. 8, No. 4, Feb. 15, 1967.

Having conceded that much to each other, they decided to commission a study which would first dig out some of the missing facts --hopefully to point the way to better answers to the problem. With the approval of the Audubon Society and the Wool Growers Association, the Bureau of Sport Fisheries and Wildlife will appoint a team of investigators who have experience in the habits of sheep and in the habits of the golden eagle. The work of the investigators will be closely supervised by the policy committee to reassure objectivity in the study. They hope to carry the study through a winter-spring lambing season, from Texas north to Montana.

RAPTOR RESEARCH AND THE NORTH AMERICAN NEST-RECORD CARD PROGRAM

A letter from Dr. David B. Peakall remarks on the following which should be of use to our members.

"It seems to me that our two organizations could be of mutual assistance to each other. The North American Nest Record Card Program has been organized to collect, analyze and distribute information on the breeding biology of birds. One of the important functions of this program is to act as an environmental monitoring system by measuring breeding success of birds on a continent-wide basis. Naturally one of the most interesting groups, judging by the marked decrease in the last decade, are the birds-of-prey. They are also one of the most difficult groups since their nests are not found and examined in large numbers.

"We hope that members of your organization will complete cards --a few are enclosed--on all active nests found. It would also be extremely valuable if they would also fill out cards on nests from previous seasons if they have detailed records. It would not be necessary to be specific as regards location of the nest, merely the state would be enough. I hope that you will be willing to publish an appeal for records in your newsletter.

"The data collected on hawks from all sources by the nest record card program will be available to any serious worker in the field."

We hope that many of our members will cooperate in this venture. Please request cards from, and return them to:

North American Nest-Record Card Program
Cornell Laboratory of Ornithology
33 Sapsucker Woods Road
Ithaca, New York 14850

COMMENTS AND QUERIES

The editors hope our readers will use this section to broadcast their questions to other readers. If you can aid our inquirers, we hope you will write directly. If the answers are of general interest, we would like a report for the News.

Request for information. Mr. Herman H. Sampson, Department of Psychology, University of Waterloo, Waterloo, Ontario, Canada, writes:

"I have started a group of researchers here at the University to investigate the visual abilities of the raptor. At the present we are trying to measure the visual acuity of the Red Tail. We have six, four females. I would be greatly interested in contacting anyone that has any information and/or ideas regarding the visual abilities of birds of prey."

Reply to Queries on Book by Prestwich. There have been several requests for a complete citation of this book: Prestwich, Arthur A., "A Record of Raptors Bred in Captivity" Arthur A. Prestwich, 61 Chase Road, Oakwood, London N.14, printed in 1955 by Stephen Austin and Sons, Ltd., Hertford. The editors are not aware whether this book is still in print.

BREEDING PROJECTS - Late News

Austing's Red-tailed Hawks. The pair which last year successfully reproduced in captivity laid three eggs this year. At last report two have hatched and one is pipped. This is the third year this pair has produced fertile eggs.

Beebe's Peregrine Falcons. One egg has hatched and a second is pipped of the second clutch of four eggs.

Kendall's Prairie Falcons. The second clutch had begun to hatch at last report.

EDITORS' NOTE

The editors are trying to get each issue out in the month on the masthead. We hope to receive all items for the next issue before June 30.

PEREGRINES AND PESTICIDES IN ALASKA*

by

T.J. Cade, C.M. White, and J.R. Haugh

INTRODUCTION

The peregrine falcon (Falco peregrinus) is a wide-ranging predator, formerly of nearly cosmopolitan distribution. Breeding populations still occur on every continent and on most of the larger islands of the world. The species is most common as a breeding bird in the Northern Hemisphere and reaches maximum densities in the north temperate maritime, subarctic, and low arctic latitudes.

Peregrines are well-known for their tenacity in holding to traditional nesting sites--usually cliffs--year after year; and their breeding populations have been characterized by a high degree of stability through time (Hickey, 1942; Ferguson-Lees, 1951; Cade, 1960; Ratcliffe, 1962)--even in the face of extensive human modification and disruption of the environment. In Great Britain, where the species has been most intensively studied, until recently the breeding population of some 600 pairs appears to have changed little since Elizabethan times, when these falcons were much in demand for the sport of falconry and many individuals were removed from the wild population each year.

Moreover, peregrine populations have shown remarkable recuperative powers in the face of deliberate decimation by man. During the period 1939 to 1944, peregrines nesting along the southern shores of England were systematically shot off their cliffs or trapped, and their eggs and young were destroyed in the nest, because these falcons reputedly interfered significantly with carrier pigeons in use by the military across the channel. Once the war was over, the peregrines very quickly began reoccupying their former nesting cliffs along these shores (Ferguson-Lees, 1951; Ratcliffe, 1962). In many parts of its worldwide range, observers have noted that adult falcons which are removed from their breeding sites are rapidly replaced by other adults, apparently from a "reservoir" of unmated individuals in the population. Thus, historically, peregrine populations have demonstrated a notable capacity to maintain stability of breeding pairs within a wide range of

*Editors' Note: We are happy to have Dr. Cade's offer of this report on recent work in Alaska. This is taken from a final report on contract no. 14-16-0008-751 between Department of the Interior and Syracuse University on which Cade was principal investigator, White associate investigator, and Haugh, field assistant. The appendices are not included; Table 1 is also omitted because of the editors' reluctance to identify specific nest sites. We wish to thank the Director, Patuxent Wildlife Research Center, Bureau of Sport Fisheries and Wildlife, to whom the report was made, for permission to include it in the News.

environments, over long periods of time, and under varying degrees of mortality, including systematic destruction by man.

Quite suddenly in recent years many of these once vigorous breeding populations, particularly in north temperate regions of intensive human occupance, began to show peculiar reproductive failures, followed after a time by disappearance of the adults from their nesting sites. This turn of events was so unexpected and so subtle in its initial manifestation that there was little chance to document the details of this unprecedented population decline as it was happening. Fortunately, a few people in widely scattered places had their eyes open, and at the Peregrine Conference held at the University of Wisconsin in 1965, the full extent of this population decline both in North America and in Western Europe was documented and evaluated by peregrine experts from several countries (Hickey, et al., in press).

The various regional reports given at the Peregrine Conference show that the species has experienced simultaneous, catastrophic population declines over much of North America and Europe. The peregrine is now extinct as a breeding bird in the eastern United States from the Mississippi Valley right to the Atlantic Coast and from Alabama north at least to Nova Scotia, a region that used to contain about 300 nesting sites known to be more or less continually occupied by breeding peregrines. Herbert and Herbert (1965) have presented some details about one local population in this region, and other examples will be found in the published version of the Peregrine Conference. Peregrines have also virtually disappeared from an extensive breeding range in Ontario. Reductions have been reported in all regions west of the Mississippi River where any kind of recent study has been carried out (see, for example, Enderson, 1965); and in particular numbers are greatly reduced all along the Pacific Coast, where peregrines were until a few years ago fairly common breeders. In Europe, peregrines have declined drastically not only in countries of high human population and intensive agriculture, such as Great Britain, Germany, and France, but also in the more remote regions of Sweden and Finland (Hickey, et al., in press).

The available evidence strongly implicates the biological concentration of residues of the chlorinated hydrocarbons (pesticides) in the peregrine's food-chain as the cause of its widespread decline in North America, Europe, and Great Britain. The main points were brought out quite clearly at the Peregrine Conference. These are: (1) reproductive malfunctions and population decline show a close temporal correspondence with the beginning of intensive industrial and agricultural uses of pesticides following World War II; (2) the geographic pattern of decline and disappearance corresponds closely with the geographic pattern of pesticide utilization--where pesticides have been heavily used, the peregrines are gone; where these chemicals are little used, peregrines still breed in their former numbers, with some local exceptions that can probably be explained by heavy contamination of the falcons on their wintering grounds (the Finnish population, for example); (3) peculiar reproductive

abnormalities, such as egg-eating, appear in a stricken population first, persist for a number of years during which there is little or no reproduction, to be followed finally by disappearance of the adults from their long-established aeries; and (4) in the one region (England) where residue analyses of peregrine carcasses and eggs have been made previously, inordinately high residue levels of chlorinated hydrocarbons have been found (Ratcliffe, 1965a and b; Jefferies and Prestt, 1966).

Alaska is the only state in the union where breeding peregrines are still common and apparently unaffected as yet by the widespread decline that has taken hold of the continental population farther south. Since our earlier studies (Cade, 1960; White, in press) provide a broadly based background of information about the population characteristics of Alaskan peregrines, we felt that an intensive re-examination of a well-known local breeding population of far northern peregrines might be valuable as a comparative basis for a further evaluation of the hypothesis that biological concentration of persistent residues of chlorinated hydrocarbons in the peregrine's food-chain is the factor responsible for the population decline. If the Alaskan peregrines are just approaching the critical, initial phase of decline, we thought it would be particularly important to obtain current information on reproductive and population characteristics that could be associated with pesticide residues in the prey and tissues of these falcons.

Our earlier studies had also shown that breeding populations convenient for study exist along most of the major rivers of Alaska, such as the Colville and the Yukon. We chose the latter for this investigation, because there had been some unverified reports that peregrines are decreasing in this region.

MATERIALS AND METHODS

White and Haugh used a 28-foot, flat-bottomed river boat, powered by a 50 hp outboard motor, for transportation during the field work. Four complete trips were made over the course of the study area from Circle, Alaska to Castle Rock, Y. T., a distance of about 172 river-miles, as measured by a "Tacro" tacrometer on U.S.G.S. maps with a scale of 1:63360. These trips were made between 10 June and 31 July 1966. The two earlier trips allowed the investigators to gather information at a time when there were downy young and/or eggs in the peregrine nests, and the two later trips were made at a time when there were advanced nestlings or fledglings present, so that a fair estimate of reproductive success was obtained.

Wherever possible, actual nesting sites (aeries) of the falcons were climbed to and examined at close hand. Of the 17 pairs of falcons observed, one pair occupied a cliff too remote from the river to examine, one aerie could not be climbed to, although it was observed to be active, and two pairs evidently had no nests; the other 13 nests were found and examined. The following data

were obtained at all aeries visited: number of eggs or young; sex ratios of young; food items in and about the nest; distance of site above the river, above base of cliff, below brink of cliff, back from the water's edge; area of nesting ledge; and other miscellaneous physical data. All young suitably aged for banding were given FWS numbered leg-bands. Records were kept on the actions of the adults at their aeries and on the development of the young. Notes were also made on local ecological conditions that may affect hunting territories, prey selection, and nest-site selection.

All bird specimens for pesticide analysis were collected either with a .12 or .410 gauge shotgun or with a mist-net. Nestling falcons, however, were simply killed by collapsing their lungs.

Specimens were preserved in a 10% formalin solution made up from well water obtained at Eagle, Alaska. Whole specimens of the smaller species were preserved, but larger species were cut up, and the brain, pectoral muscle, liver, and some abdominal fat were preserved in separate containers. Whole specimens were first weighed intact. They were then skinned, and bills, legs, and wings beyond the first joint out from the body were removed. The specimens were again weighed and placed into acetone-washed jars with formalin. Lids on the preserving jars were lined with aluminum foil, and the jars were sealed with wax to prevent leakage.

Several mammals were taken in snap traps and preserved in the same way as the birds. Fresh, intact items of food found in the aeries were also preserved.

The specimens obtained for analysis of pesticide residues came from both resident and migrant populations, and the species sampled were chosen on the basis of known prey items as determined by the present and previous field studies in this area.

Appendix A presents all pertinent data obtained on the specimens in the field.

The pesticide residue analyses were carried out by the Wisconsin Alumni Research Foundation. Appendix B presents details of the procedures used, as well as the complete findings on each sample analyzed. Eighty-four separate analyses were performed.

RESULTS AND DISCUSSION

Distribution and density of breeding pairs. In 1966, 17 pairs of peregrines were found along 172 miles of river. Table 1 shows the relative locations of the cliffs occupied by these pairs and compares the 1966 distribution with that found in 1951 (Cade, 1960). The average linear distance between occupied cliffs in 1966 was 10.5 miles (range of 31 to 2 miles). In 1951 the average distance between 19 occupied cliffs was 9.3 miles (range of 31 to 2.75 miles). Traveling the same stretch of river in the latter part of the nestling period in 1899, L. B. Bishop and W. H. Osgood (1900)

estimated that there was about one pair every 10 miles, remarkably good agreement with our actual counts made 52 and 67 years later.

Thirteen cliffs are known to have been used both in 1951 and 1966, and the number could have been higher as some pairs may have been overlooked in both years. At least four specific cliffs have histories of occupancy exceeding 30 years, and two located between Eagle and Dawson (one outside the present area of consideration) have been occupied for more than 65 years.

These Yukon falcons conform to the classic picture of a breeding peregrine population: a static number of pairs, each associated with a specific and long used aerie. Numbers have not decreased in recent years, and there is no reason to think that peregrines were ever more common on the upper Yukon than they are at present.

It is instructive to compare the distribution of occupied cliffs listed in Table 1 with the total number of "suitable" nesting cliffs on this stretch of the Yukon. From our knowledge of the kinds of sites chosen for nesting by these peregrines, we judge there are at least 35 cliffs potentially available for nesting on this stretch of river. The average distance between all cliffs is 4.9 miles (range of 1.4 to 12.5 miles). Obviously some factor other than available nesting habitat is limiting this breeding population. Since in six of the cases listed in Table 1 the distance between adjacent pairs was not more than 3 miles, it seems probable that territorial aggression also is not a limiting factor, as suggested by Ratcliffe (1962) for the much denser British population prior to its decline.

The sector of river between cliffs numbered 17 and 27 was especially sparsely occupied, only three pairs in each year spread among 11 cliffs. It is unlikely that density of food species per se varies sufficiently along this stretch of river to produce the observed variability in the linear distribution of peregrine aeries; but the variation in suitability of the surrounding terrain for hunting by peregrines may be the factor. This aspect of peregrine ecology needs more study than it has so far received.

Reproductivity of the Yukon peregrines. On the average, northern peregrines lay about 3 eggs, and the number of young chicks ranges around 2.3 to 2.7 per aerie, indicating that about 1 or 2 eggs out of 10 are lost even among successful pairs (Cade, 1960). In 1966, the mean number of downy chicks and/or eggs for 11 productive pairs on the upper Yukon was 3.09, and the mean number of advanced young was 2.25 per aerie for 12 pairs, compared with only 1.67 young per successful pair in 1951. (The 1951 figure is based on an assessment made at a somewhat later stage of the breeding period than was the case in 1966.) The mean number of fledged or nearly fledged young per occupied cliff (includes successful and unsuccessful pairs) was 1.80, as compared with 1.05 in 1951, and 1.4 for 25 aeries along the Colville in 1952 (Cade, 1960). Thus, by all prior standards of comparison available on far northern populations, the reproductivity of the Yukon peregrines in 1966

must be judged to lie on the high side of the over-all average figure of about 1 young fledged per occupied site. (See Table 2.)

The Yukon figure for 1966 also compares well with other samples of productivity obtained from more southern populations before the present decline set in; but in evaluating these comparisons it must be kept in mind that the average number of eggs produced by these southern falcons was four rather than three. For instance, Hickey (1942) reported an average of 1.5 young raised for 19 occupied aeries around New York in 1939 and 0.7 young for the same 19 sites in 1940. Herbert and Herbert (1965) found an average of about 2.0 young per aerie along the Hudson River during the years 1941-1945; and Beebe (1960) judged that the population of F. p. pealei on Langara Island produces about 2 young per pair, although his observed average of 2.7 young per productive pair is no greater than for more northern populations and his surveys were carried out at a time when it was impossible to determine the number of unsuccessful pairs in the starting population. The reproductivity of the Yukon peregrines in 1966 also exceeds the two best years reported for 14 Massachusetts aeries between 1935 and 1942 (Hagar, in press).

Food of the Yukon peregrines. Three hundred and twenty-nine items of prey were found around the aeries in 1966, and these are compared in Table 3 with the 226 items found in 1951 (Cade, 1960). The data for the two years are quite similar in general outline and show that these peregrines sampled widely from the available avifauna, although certain types of birds were more prone to capture than others. A few mammals were also taken. Waterfowl constituted about 50 per cent of the diet by weight; pintails (Anas acuta), green-winged teal (Anas carolinensis), and shovelers (Spatula clypeata) were among the most frequently taken species. Shorebirds constituted 10 to 12 per cent of the food by weight; the common snipe (Capella gallinago), spotted sandpiper (Actitis macularia), and lesser yellowlegs (Totanus flaviceps) were most often caught. Small gulls made up about 10 to 15 per cent. Small land birds (Piciformes and Passeriformes) constituted about 20 per cent; and among these, the yellow-shafted flicker (Colaptes auratus), gray jay (Perisoreus griseus), American robin (Turdus migratorius), varied thrush (Ixoreus naevius), and various hylocichlid thrushes were hardest hit. Small mammals made up 2 to 3 per cent of the food.

The peregrine is a top predator in its ecosystem, feeding on primary, secondary, and tertiary carnivorous species, as well as on herbivores. In some cases its trophic level may be removed from the producer level by as many as five or six links in the food-chain (plant-herbaceous insect-predatory insect-insectivorous bird-small hawk or owl-peregrine), a fact of particular significance in connection with biological concentration of pesticide residues up the peregrine's food-chain. The great bulk of the summer food of this Yukon population is made up of migrant birds, only 10 to 15 per cent of the total consumed biomass consisting of resident species of prey. About half of the total weight of food consists of species that are primary or secondary carnivores, and about half, of species that are

herbivores or mixed herbivores and carnivores. All these points have an important bearing on the pesticide-peregrine food-chain hypothesis.

Pesticide residues in Yukon peregrines and their prey. Table 4 summarizes the results obtained from residue analyses on 36 whole specimens of prey from the Yukon. In general these results conform to expectation, although we were surprised to find measurable amounts of residues in resident species. Resident species averaged only a few tenths ppm (dry weight) of DDE, DDD, and DDT, and contained no measurable amounts of dieldrin or other chlorinated hydrocarbons. Migrant species of seed-eating birds (primary consumers) contained about the same quantities. Migrant sandpipers were rather high in DDE (several ppm dry weight) but were low in DDD and DDT; but they all contained measurable amounts of dieldrin. Migrant insectivorous birds tended to run somewhat higher in DDE, DDD, and DDT than either migrant seed-eaters or residents, and several of them also contained dieldrin. Abdominal fat from two ducks (a surf scoter, Melanitta perspicillata, and a white-winged scoter, Melanitta deglandi) averaged 1.36 ppm (dry weight) of DDE, 0.478 ppm of DDD, 0.304 ppm of DDT, and no dieldrin; while fat from two mew gulls (Larus canus) averaged 46.2 ppm of DDE, 2.13 ppm of DDD, 2.12 ppm of DDT, and 0.179 ppm of dieldrin.

All peregrine materials and tissues contained measurable amounts of DDE, DDD, and DDT, sometimes in rather high concentrations, and most tissues also contained some dieldrin (Table 5). No other chlorinated hydrocarbon residue was found. Whole eggs and chicks contained tens of ppm (dry weight) of DDE, and several ppm each of DDD, DDT, and dieldrin. These residues were about 10 to 100 times more concentrated in these eggs and chicks than they were in the prey species.

Adult tissues, especially fat, contained the highest concentrations of residues. Total residues for adult fat averaged 679 ppm (dry weight), of which 622 ppm was DDE. Pectoral muscle was the next highest, total residues averaging 99.8 ppm dry weight (89.2 ppm DDE). Brain was third, 26.0 ppm total residues (22.6 ppm DDE); and liver was a close fourth, 24.1 ppm total residues (20.9 ppm DDE). It appears that residues in adult peregrine tissues run around 100 to 1000 times more concentrated than in the Alaskan prey of these falcons.

It is interesting to compare levels in the tissues of juveniles (4 to 6 weeks old) with levels in the same tissues of adults. In general, the levels for any given tissue were 10 to 20 times higher in adults than in juveniles; yet in only a few weeks of life, the juveniles appear to have achieved significantly higher levels of residues than commonly occur in their food species.

These data show that even in so remote a region as interior Alaska, the peregrine's food-chain is contaminated with significant, measurable quantities of persistent residues of the chlorinated hydrocarbons, and they support the hypothesis--first developed in

Great Britain (Moore and Ratcliffe, 1962; Ratcliffe, 1963)--that there is a biological concentration of these residues in the tissues of peregrines. But how does one explain the association of high residue levels in these peregrines with an undiminished population and unhampered reproduction? Either the hypothesis that the decline in peregrine populations elsewhere has resulted from the effects of pesticides is incorrect, or else these Yukon peregrines must be precariously poised near some threshold level that will prove inimical once reached.

Although there is some evidence to suggest that peregrines can attain lethal levels of pesticide residues in nature (Ratcliffe, 1965; Jefferies and Prestt, 1966; see also, Stickel et al., 1966, for a comparison with experimentally induced lethal levels in several species), most advocates of the pesticide-peregrine hypothesis have felt that the population decline was brought about--at least initially--by sub-lethal effects associated in some way with reproductive failure. A difficulty of this hypothesis has been that the exact mechanism of these sub-lethal effects is unknown, nor is there a clear-cut association between a given level of pesticide residues and a particular kind of reproductive failure.

Most investigators have worked on the assumption that the effect on reproduction in birds must be a fairly direct one--causing infertility of eggs or abnormal embryonic development--and consequently quite a number of eggs of birds of prey have now been analyzed for pesticide residues. Even taking into account differences of technique and methods of expressing results, the emerging picture is far from clear. Ratcliffe (1965), reporting on a series of 15 British peregrine eggs, found total residues ranging from 5.5 ppm (wet weight) to 36.1 ppm. Most of these eggs came from aeries that experienced some form of reproductive failure. On the other hand, our two eggs taken from a reproductively sound population, when expressed on a comparable basis, give a value for total residues of about 14.3 ppm (wet weight) and fall near the average value of the British eggs. Enderson and Berger (unpublished manuscript) found even higher values in eggs from peregrines nesting in northwestern Canada in 1966. In contrast, Ames (1966), working with the obviously sick and reproductively failing population of ospreys (Pandion haliaetus) along the Connecticut River, obtained much lower values of DDE, DDD, and DDT in eggs, with an average of only 6.5 ppm (wet weight). Even so, this average was about twice as high as the average for osprey eggs from the Potomac, where reproduction was much better. Keith (1966) got really high values, averaging 226.8 ppm (wet weight) total residues, in 9 eggs from a colony of herring gulls (Larus argentatus), which experienced low reproductive success on islands in Green Bay, Lake Michigan. Species differences, or even local population differences, in susceptibility to pesticide effects may be involved in some of these striking variances, although the levels in brain associated with death seem to be rather uniform among a variety of species (Stickel et al., 1966).

Ratcliffe's (1958; 1963; 1965) perceptive observations on egg-eating and frequent abandonment of eggs or young by adult peregrines during the decline in Great Britain suggest that the pesticide effect may be initially, if not primarily, on the reproductive physiology and behavior of the breeding adult falcons. He suggested that because most of the chlorinated hydrocarbons are nerve poisons there might be a primary action on nervous mechanisms involved in reproductive behavior. Recent work by pharmacologists suggests an alternative mechanism that fits very well with these observed behavioral abnormalities.

Several workers have shown that chlorinated hydrocarbons such as chlordane and DDT stimulate the induction of drug-metabolizing enzymes in the livers of rats, mice, rabbits, guinea pigs, and squirrel monkeys (Hart et al., 1963; Hart and Fouts, 1963; 1965; Fouts and Hart, 1965; Cram et al., 1965; Kuntzman and Jacobsen, 1965; Conney et al., 1966; Conney et al., 1967). These drug-metabolizing enzymes also hydroxylate steroid hormones such as progesterone, and hydroxylation of a steroid can interfere with its biological function. (We are indebted to Dr. David Peakall for drawing our attention to this literature.)

Many of the steroid hormones (sex hormones) are known to be involved in the potentiation and maintenance of various forms of reproductive behavior, and they often have complex sequential and synergistic co-actions on a given mode of behavior. Progesterone, for example, is known to act synergistically with prolactin, or alone, to maintain various modes of maternal behavior, such as broodiness (Riddle, 1963; Lehrman, 1963). Certainly the induction of an enzyme that can alter steroid structure offers the possibility of a powerful mechanism that could introduce abnormalities in behavior and physiology of the reproductive cycle at any point--from the initiation of courtship activities, through copulation, ovulation, incubation, and finally parental care of the young, depending on which hormones were affected. The high DDE levels so characteristic of residues in peregrines and other top avian predators may indicate that the induced drug-metabolizing enzymes have been at work for a long time; if so, they may also be indicative of a high percentage of altered steroid hormone molecules. How many molecular abnormalities does it take to produce abnormal behavior? Work along these lines should be initiated on birds as soon as possible.

In conclusion, while we are much encouraged to be able to report that this Yukon population of peregrines is still intact and reproducing at a normal rate, the widespread occurrence of pesticide residues at rather high levels in the eggs and tissues of these falcons allows us no sanguine feeling about their future. If other associative evidence is a valid criterion--and we think it is--then these falcons must be perilously balanced near the threshold level of pesticide residues that initiates dysgenic reproductive behavior and eventual population decline. As their fate may well depend on how these residues continue to accumulate,

these Yukon peregrines certainly should be watched closely over the next few years for evidence of reproductive malfunction coincident with continued, or increasingly, high levels of residues of the chlorinated hydrocarbons in their tissues.

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Table 2. Reproductivity of peregrines nesting along the Yukon River.

Number at aerie	Down chicks and/or eggs, 1966 only	Fledged or nearly fledged young	
		1951 ⁺	1966 ⁺⁺
0	2	7 ⁺⁺⁺	3
1	1	6	3
2	3	4	4
3	1	2	4
4	6	0	1
Total	34	20	27
Mean of produc- tive pairs	3.09	1.67	2.25
Mean per occupied cliff	2.72	1.05	1.80

⁺Revised from Cade (1960). ⁺⁺Figures include predation by investigators on eggs and young. ⁺⁺⁺Figure includes 3 cliffs where only single adults were found in 1951 but where pairs are known to have nested in other years.

Table 3. The prey of peregrines in the taiga zone of Alaska.

Species	Weight class in grams	No.	1951 ⁺ & Total	% Weight	No.	1966 % Total	% Weight
Red-necked Grebe	500	1	0.44	1.44	1	0.30	1.10
Horned Grebe	250	-	-	-	3	0.91	1.87
Black Brant	1400	1	0.44	4.00	-	-	-
Pintail	900	5	2.21	12.78	3	0.91	5.93
Green-winged Teal	300	7	3.09	6.00	9	2.76	5.93
Blue-winged Teal	300	-	-	-	2	0.60	1.32
Unidentified teal	300	-	-	-	2	0.60	1.32
American Widgeon	550	-	-	-	2	0.60	2.41
Shoveler	550	2	0.88	3.14	5	1.53	6.04
Canvasback	1300	1	0.44	3.71	-	-	-
Scaup ducks	600	3	1.33	5.14	1	0.30	1.32
Harlequin Duck	600	1	0.44	1.71	-	-	-
White-winged Scoter	1250	-	-	-	1	0.30	2.75
Surf Scoter	900	1	0.44	2.57	2	0.60	3.95
Unidentified ducks	500 ⁺⁺	4	1.76	5.72	17	5.19	18.68
<u>Waterfowl subtotal</u>	-	26	11.50	46.35	48	14.60	52.62
American Kestrel	110	-	-	-	1	0.30	0.24
Spruce Grouse	550	1	0.44	1.57	1	0.30	1.21
Ruffed Grouse	550	1	0.44	1.57	-	-	-
Common Snipe	100	20	8.84	7.72	20	6.07	4.39
Upland Plover	150	1	0.44	0.42	-	-	-
Spotted Sandpiper	40	23	10.17	2.63	10	3.03	0.88
Lesser Yellowlegs	80	6	2.65	1.37	26	7.93	4.57
Solitary Sandpiper	40	-	-	-	9	2.76	0.79
Pectoral Sandpiper	60	-	-	-	1	0.30	0.13
Semipalmated Sandpiper	30	2	0.88	0.17	-	-	-
Northern Phalarope	25	1	0.44	0.07	3	0.91	0.16
Unidentified Shorebirds	50 ⁺⁺	-	-	-	10	3.03	1.10
<u>Shorebird subtotal</u>	-	53	23.51	10.39	79	24.03	12.02
Mew Gull	500	11	4.86	15.73	3	0.91	3.30
Bonaparte's Gull	250	2	0.88	1.44	5	1.53	2.74
Sabine's Gull	250	-	-	-	1	0.30	0.55
Arctic Tern	110	-	-	-	1	0.30	0.24
Unidentified larids	250 ⁺⁺	-	-	-	4	1.21	2.20
Hawk Owl	350	1	0.44	1.00	-	-	-
Boreal Owl	80	-	-	-	1	0.30	0.18
Yellow-shafted Flicker	90	13	5.75	3.34	11	3.35	2.18
Unidentified woodpeckers	60	-	-	-	2	0.60	0.26
Empidonax flycatchers	10	1	0.44	0.02	7	2.18	0.15
Olive-sided Flycatcher	30	1	0.44	0.06	-	-	-

Table 3. Continued.

Say's Phoebe	20	-	-	-	1	0.30	0.04
Bank Swallow	10	1	0.44	0.02	1	0.30	0.02
Cliff Swallow	15	-	-	-	1	0.30	0.03
Gray Jay	80	24	10.60	5.49	63	19.15	11.07
Black-capped Chickadee	10	1	0.44	0.02	-	-	-
Hudsonian Chickadee	10	1	0.44	0.02	-	-	-
American Robin	80	9	3.98	2.05	8	2.43	1.41
Varied Thrush	70	10	4.42	2.00	16	4.87	2.46
Hermit Thrush	30	-	-	-	1	0.30	0.07
Swainson's Thrush	30	-	-	-	3	0.91	0.20
Unidentified hylocichlids	30	13	5.75	1.11	10	3.03	0.66
Townsend's Solitaire	30	-	-	-	1	0.30	0.07
Bohemian Waxwing	60	3	1.33	0.51	9	2.76	1.19
Orange-crowned Warbler	10	1	0.44	0.02	1	0.30	0.02
Yellow Warbler	10	1	0.44	0.02	2	0.60	0.04
Unidentified warblers	10 ⁺⁺	-	-	-	2	0.60	0.04
Rusty Blackbird	50	6	2.56	0.85	2	0.60	0.22
Redpoll	10	1	0.44	0.02	-	-	-
Pine Grosbeak	40	1	0.44	0.11	1	0.30	0.09
White-winged Crossbill	30	5	2.21	0.42	-	-	-
Slate-colored Junco	10	2	0.88	0.05	6	1.82	0.13
Fox Sparrow	35	11	4.86	1.10	6	1.82	0.47
White-crowned Sparrow	25	-	-	-	2	0.60	0.11
<u>Piciform and Passerine</u> <u>Subtotal</u>	-	118	52.60	19.51	176	54.42	22.45
Dusky Shrew	5	5	2.21	0.07	-	-	-
Voies, spp.	30	6	2.26	0.51	2	0.60	0.13
Red-backed Vole	30	-	-	-	2	0.60	0.13
Arctic Ground Squirrel	400	-	-	-	1	0.30	0.88
Snowshoe Hare	500	2	0.88	2.86	1	0.30	1.10
<u>Mammal subtotal</u>	-	13	5.77	3.44	6	1.80	2.44
<u>Grand Total</u>	-	226	100.00	100.00	329	100.00	100.00

⁺Based on table 7 of Cade (1960).

Table 4. Summary of pesticide residues in Alaskan prey of peregrines.

Pesticide	Prey category	No.	ppm dry weight Mean Range	ppm lipid weight Mean Range
DDE	A	17	1.05 (0.269-3.94)	12.2 (2.48-41.8)
DDE	B	7	0.473 (0.069-1.48)	5.41 (0.677-14.3)
DDE	C	4	6.02 (1.94-10.5)	48.1 (7.71-129.0)
DDE	D	8	0.316 (0.066-0.987)	7.71 (0.825-35.1)
DDD	A	17	0.170 (0.051-0.323)	2.21 (0.480-5.33)
DDD	B	7	0.121 (0.062-0.281)	1.61 (0.308-3.67)
DDD	C	4	0.073 (0.059-0.095)	0.582 (0.210-0.900)
DDD	D	8	0.105 (0.066-0.147)	1.98 (0.770-4.01)
DDT	A	17	0.157 (0.051-0.323)	2.11 (0.357-6.15)
DDT	B	7	0.120 (0.062-0.281)	1.58 (0.332-3.67)
DDT	C	4	0.087 (0.070-0.130)	0.412 (0.136-0.972)
DDT	D	8	0.191 (0.066-0.740)	1.77 (0.408-4.18)
Dieldrin	A	17	0.010 (0.000-0.099)	0.067 (0.000-0.675)
Dieldrin	B	7	0.000 -	0.000 -
Dieldrin	C	4	0.112 (0.044-0.274)	0.965 (0.173-2.59)
Dieldrin	D	8	0.000 -	0.000 -

- A - Migrant insectivorous passerines: 2 Traill's flycatchers, 2 bank swallows, 2 American robins, 3 varied thrushes, 3 Swainson's thrushes, 2 gray-cheeked thrushes, 1 yellow warbler, 1 northern waterthrush, and 1 rusty blackbird.
- B - Migrant seed-eating passerines: 2 slate-colored Juncos, 3 white-crowned sparrows, and 2 fox sparrows.
- C - Migrant sandpipers: 3 spotted sandpipers and 1 lesser yellowlegs.
- D - Resident boreal birds: 2 juvenile ruffed grouse, 5 gray jays, and 1 pine grosbeak.

Table 5. Pesticide residue in the tissues of Alaskan peregrines.

Pesti- cide	Tissue analyzed	No.	ppm dry weight Mean Range	ppm lipid weight Mean Range
DDE	Eggs	2	48.0 (44.0-52.0)	330.0 (190.0-469.0)
DDE	Downy chicks	2	38.4 (28.8-48.5)	381.0 (372.0-391.0)
DDE	Juvenal fat	4	42.4 (17.5-56.3)	46.2 (19.6-59.8)
DDE	Adult fat	4	622.0 (176.0-914.0)	778.0 (186.0-1335.0)
DDE	Juvenal muscle	4	6.33 (0.836-14.6)	61.8 (11.5-125.0)
DDE	Adult muscle	4	89.2 (51.8-135.0)	513.0 (236.0-950.0)
DDE	Juvenal liver	4	1.57 (1.27-1.92)	33.6 (23.6-43.2)
DDE	Adult liver	4	20.9 (7.33-33.4)	415.0 (117.0-790.0)
DDE	Juvenal brain	4	1.64 (0.512-2.99)	8.52 (2.69-14.4)
DDE	Adult brain	4	22.6 (8.32-29.0)	103.0 (35.2-128.0)
DDD	Eggs	2	3.35 (0.408-6.29)	15.4 (3.68-27.2)
DDD	Downy chicks	2	3.65 (2.74-4.56)	41.5 (21.1-61.9)
DDD	Juvenal fat	4	1.29 (0.239-2.33)	1.45 (0.254-2.67)
DDD	Adult fat	4	25.4 (5.07-48.0)	28.5 (7.41-53.4)
DDD	Juvenal muscle	4	0.167 (0.066-0.464)	1.77 (0.465-3.95)
DDD	Adult muscle	4	4.04 (1.50-5.74)	20.5 (10.6-25.2)
DDD	Juvenal liver	4	0.090 (0.060-0.177)	2.15 (1.04-5.08)
DDD	Adult liver	4	1.42 (0.273-2.20)	26.4 (7.63-51.5)
DDD	Juvenal brain	4	0.212 (0.092-0.564)	1.07 (0.480-2.72)
DDD	Adult brain	4	1.41 (0.310-2.40)	6.36 (1.36-10.8)
DDT	Eggs	2	3.02 (1.02-5.02)	10.5 (9.20-11.7)
DDT	Downy chicks	2	2.41 (2.14-2.69)	24.8 (20.6-29.1)
DDT	Juvenal fat	4	1.24 (0.754-1.54)	1.36 (0.845-1.69)
DDT	Adult fat	4	25.3 (11.2-48.0)	29.1 (16.3-53.4)
DDT	Juvenal muscle	4	0.157 (0.066-0.397)	1.63 (0.465-3.38)
DDT	Adult muscle	4	1.93 (0.272-3.63)	4.85 (1.92-13.7)
DDT	Juvenal liver	4	0.085 (0.060-0.156)	1.99 (1.04-4.43)
DDT	Adult liver	4	1.03 (0.546-1.25)	20.0 (17.4-31.7)
DDT	Juvenal brain	4	0.189 (0.092-0.473)	0.956 (0.480-2.28)
DDT	Adult brain	4	1.10 (0.600-1.57)	4.88 (2.64-7.04)
Dieldrin	Eggs	2	2.75 (1.45-3.06)	16.9 (6.27-27.6)
Dieldrin	Downy chicks	2	0.861 (0.784-0.938)	9.36 (6.02-12.7)
Dieldrin	Juvenal fat	4	0.149 (0.046-0.385)	0.164 (0.048-0.423)
Dieldrin	Adult fat	4	6.20 (1.45-15.1)	7.37 (1.52-17.4)
Dieldrin	Juvenal muscle	4	0.051 (0.000-0.134)	0.525 (0.000-1.14)
Dieldrin	Adult muscle	4	4.59 (0.781-10.9)	28.1 (4.05-77.3)
Dieldrin	Juvenal liver	4	0.083 (0.000-0.184)	1.87 (0.000-4.14)
Dieldrin	Adult liver	4	0.720 (0.312-0.988)	13.5 (8.72-20.8)
Dieldrin	Juvenal brain	4	0.000 -	0.000 -
Dieldrin	Adult brain	4	0.850 (0.322-1.60)	5.49 (1.36-7.82)